A. General Comments

This MS aims to present a practical approach for quantitative assessment of beach erosion risk potential, induced by three common factors in coastal environments. These include reduction of sediment supply from updrift river, shoreline change due to construction of harbor breakwater, and erosion caused by high wave attack. The methodology outlined in the MS is rational and the analysis is supported by approximate formulae, empirical model and field data derived from arial photographs and beach survey for a case study at Bongpo-Cheonjin Beach in Korea. Overall, the content in this MS is well constructed and balanced with theory for quantitative assessment of beach erosion potential. It is therefore recommended for publication in the NHESS after minor revision, following, at least, the detailed suggestions listed under the original section and sub-section titles in part C below.

B. Specific Comments

1. Title of the paper: This paper has produced a useful graph (e.g., Figure 14) for estimating the combined risk potential for beach erosion from three different sources discussed in the MS. Based on the content in this paper, please consider using an alternative title of "Quantitative assessment of risk potential of beach erosion due to coastal zone development.", instead of the original title: "Quantitative interpretation of …….".

2. The key production of this paper — *encroachment accumulation curve*. This complex term has appeared many (about 10) times in 1. Introduction and 2. Beah Erosion Risk, also several times in Sect. 4. However, given the word "*encroachment*" is rarely used in beach erosion (e.g., encroachment of shoreline ?), and "*accumulation*" is not an explicit term because method to add up the components is unclear, and the adverse effect from different sources is combined, rather cumulative. Therefore, an alternative phrase called "*combined erosion potential curve*" is recommended. This term better reflects the title of this paper, as well as agrees better with the sub-section heading (Sect. 4.5) and the title of Table 3.

C. Technical Corrections & Detailed Suggestions

Detailed list of suggestions (but not exhausted) is given with line number under the original section or sub-section titles (in bold face) below, to assist the authors when revising MS.

Abstract

L10:   "amount of sand" → "amount of sediment budget from updrift"
L10–11:   Three " …changes in …,changes in …, and changes in…" in a short sentence! Please revise this repetitive expression!
L12:   "sand beach." → "sand**y** beach."
L12:   "amount of sand is due to" → "amount of sand budget is considered by"
L13–14:   "main crest line at the breaking point."   What is this ?
L15–19:   Please use the tense (present/past ?) consistently for all verbs !

Key words

L22:   Most of the current keywords are not important nor relevant. Please reconsider and select appropriate ones from the context.

1. Introduction

L39: "… sand becomes smaller than…" → "… sediment is less than…"

L41: "due to wave field changes which generate transport of longshore sediment," → "due to redistribution of longshore sediment transport,"

L42–44: " (2) a decrease in... under storm wave incidence." → Please revise this long phrase!

L48: "The beach maintains its current volume as the sediment budget is balanced." This is an awkward sentence! Something missing, or miss-use of "the"

L48–49: "... it is essential to analyze it by dividing it into..."? Too many "it" in a sentence! → Please revise!

L50: "…discharge into or leaving in the littoral cell…" → "…entering or leaving a littoral cell…"

L52 –53: "Therefore, the amount of sediment entering into the beach from the river and the amount of sediment leaving into the open sea by...should be interpreted…". → Please avoid repeating "the amount of sediment" and revise "…entering into the beach…" and "…leaving into…" !

L59: "…deposition in some areas, but at the same time, erosion in some areas." → Confusion ! Please use "accretion" rather "deposition" and revise these phrases !!

L63: "… its utility in" → " …its practicality in"

L67: "…general sand beaches." → "… most embayed beaches."

L68: "…due to the wave, …" → "… due to high waves, …"

L70–71: "estimating the erosion width by frequency…"   Why is this??

L74: "… beach erosion occurring in the beach according to the anthropogenic factors…" → "…beach erosion due to anthropogenic factors…"

L75–76: "… to the area of the erosion zone that is damaged is introduced." → "… to the eroding area is introduced."

L76: "…, a method of estimating the frequency…". "the frequency" for what

L79: "… when the impact will be competed." → "… when the estimated impact will be resulted."

L80 & L93: " ... *encroachment accumulation curve*,…" ? → Please consider using " *… combined erosion potential curve*,…" in the entire paper, because "erosion" is a most common word, rather "*encroachment*" is rarely used. In addition, "combined" is better than "*accumulation*". See also Sect.4.5 heading and Table 3 caption in the MS.

L80: "… the area of the encroached section of the beach…" → "…the area of the eroded beach section…"

L83: "The erosion width is accomplished through three different planar area;…" → "The combined erosion width comprises: …"

L87: "… evenly affects…" → "… uniformly distributed over…"

L87–88 & L142 –143: "… except for a part of the deposition section due to shoreline deformation, …" → "… except for the accretion due to shoreline reshaping,…"

L96–97: "…, with results presented are graphically in Sect. 4." → ",…and the results are presented graphically in Sect. 4."

2. Beach Erosion Risk

L109: "… apply them to real fields…" → " … apply them to field condition…"

L112: "…encroachment status …" → " … erosion status…"

2.1 Definition of beach erosion risk

L117:   "… ***F*** as shown in the following equation," → " … ***F*** given by,"
L119 & L123:   "… the right side of …"   → "… the right-hand-side of …"

2.2 Rish potential of beach erosion

L134:   "…previous two cases… for the last, …."
    → "… first two cases… for the third case…"
L137, L140–141 & L144:   " *... encroachment accumulation curve*,…"
    → Please consider using " *... combined erosion potential curve*,…"
        See explanation for   L80 & L93.
L139:   "The following introduces the method of obtaining…"
    → "The method is introduced in the following to obtaining…"
L151–L154, L159 & L165, in Figure 1 and caption & caption for Figure 2:
    "encroachment accumulation curve" → Use "combined erosion potential curve"
L155, L157 & L158:   "encroached …" → "eroded …"

2.3 Calculation process of the beach erosion risk

L173:   "encroachment accumulation curve" → "combined erosion potential curve"
L173:   "… is expressed as the following equation." → "… is expressed by,"
L177:   "…, C_l hardly occurs, …" → "…, C_l would not occur, …"
L177:   "… on the right side" → "… on the right-hand-side"
L178:   " … is judged to be insignificant…." → "…becomes insignificant…"

3. Quantitative Interpolation

L180:   "3. Quantitative Interpretation" → Revise it as "3. Quantitative Assessment" ?

3.1 Sediment budget reduction potential

L183–184:   " … to the beach of the littoral cell…"
    → "… to the beach within a littoral cell…"
L186–188:   "where… to the action of waves."
    →→ to be shortened as "Where Q_{in} is the rate of sediment input from a river and Q_{out} is the rate of sediment loss into the sea due to wave action."
L188–189:   "If we express…is established:"
    →→ to be shortened as "Expressing Q_{out} as a function of the loss rate K to a beach sediment volume V, the Eq. (7) becomes:"

3.2 Longshore sediment deposition potential

L207:   "… due to wave field changes."
    → "… due to change in wave field arising from construction of a harbor breakwater."

3.3 Cross-shore sediment retreat potential

L238–239:   "Figure 6 shows...of shoreline position."]

→→ to revise as "Figure 6 shows the mean beach profile with a near constant depth of closure and the temporal variation of shoreline position for each beach profile."

4. Case Study for Bongpo-Cheonjin Beach
4.1 Study site description

L273: "…, South Korea, has a small…" → "…, South Korea, which has a small…"
L275: "… the existence of a breakwater…" → "…the existence of the breakwater…"
L277–278: "… breakwaters of total 490 m…" → "…breakwater totaling 490 m…"

4.2 Sediment budget reduction in the study area

L298–299: "…results presented are graphically in Sect. 3.2 – 3.4."
→ "… results are presented graphically in Sect. 4.2 – 4.4."
L307–308: "The beach width extracted from the aerial photograph is the value obtained….by…by…of the shore…"
→→ "From an aerial photograph, the value of beach width is obtained from dividing the beach area by the shoreline length…"
L310: "…in the Bongpo-Cheonjin beach." → "…at Bongpo-Cheonjin beach."
L310 –311: "It is judged that the range… within the erosion width."
→ May we delete this sentence?
L312 –313: "…, since 1979.11, ...beach area …approximately 31,821 m^2...beach width…about 28.9 m."
→→ " …, that since 1979.11 total beach area at Bongpo-Cheonjin has remained around 31,800 m^2, about the average of 31,821 m^2, or higher after 2005.05, except that between 1991.11 and 2005.05, whereas beach width has maintained about 28 m or more, except in 1997.06 when it was reduced to 26.6 m."
L315: "…was also ignored as few." → "…was also ignored."

4.3 Longshore sediment deposition potential caused by construction of harbor breakwater

L317 –318: "As shown in Fig. 11, the beach width …between 2000 and 2017"
→ "As shown in Fig. 10, the beach width… after mid 2008 (by linear interpolation between 2005.05 and 2010.11)"
L325: "…A_d is obtained…" → "…A_d is then obtained…"
L331: "…is estimated as…" → "…is finally estimated as…"

4.4 Cross-shore beach retreat due to high wave incidence

L343: "from 5.57 m to 23.16 m (1 yr ≤ F_e ≤ 100 yrs)."
→ "from 5.57 m to 23.16 m (1 yr ≤ F_e ≤ 100 yrs)." ? Use non-italicized units.

4.5 Erosion risk potential at Bongpo-Cheonjin Beach

L348–349: "… factor to the *encroachment accumulation curve* as given in Chapter 2. Figure 14 shows *the encroachment accumulation curve* according to…"
→ "… factor to the *combined erosion potential curve* as given in Sect. 2. Figure 14 shows the *combined erosion potential curve* according to…"
L350: "Table 3 shows the encroachment aera…" → "Table 3 shows the combined area…"

L352–353   "…are evaluated by 0 and 17 m, …" → "…estimated are 0 and 17 m, …"

L356–357:   "…using the *encroachment accumulative curve*, …"
      → "…using the *combined erosion potential curve*, …"

L364, Figure 14 caption: "…using the encroachment accumulation curve…."
      → "…using the combined erosion potential curve…"

L367, Table 4 caption: "…using the encroachment accumulation curve."
      → "…using the combined erosion potential curve."

5. Discussion

L371–373:   "…, a risk potential was introduced as the meaning of risk when an equilibrium
      was reached for a long time, and a quantitative interpretation of risk potential was
      presented. This is, the risk potential, which is the planar area of the beach that can cause
      the maximum damage, is calculated excluding the continuous change of the shoreline
      with time scale." ?? Very confusing ??
      →→ "…, a risk potential is defined as the extent of beach erosion or shoreline retreat
      caused by a specific environmental impact factor, such as reduction of updrift sediment
      supply, change in wave field due to harbor breakwater construction, and effect of high
      wave attack."

L374:   "… it takes time for erosion to reach equilibrium state."
      → "…it takes time for an eroded beach to regain its new equilibrium status."

L374–375:   "… to properly understand the temporal change, it is required to identify more
      relevant coefficient depending on the target beach."
      →→ "… to understand the temporal beach change, all relevant data must be thoroughly
      analysed, as well as the scale of the beach erosion from each contributing factor versus
      time, because the combined erosion potential may not be resulted as a simple arithmetic
      sum. For example, that induced by high waves occurs only sporadically, whereas those
      from other two factors are continuous, as illustrated in Figure 16."

L375–376:   "Figure 16 shows the approximate time scale difference in term of beach width
      according to three different erosion occurrence elements."
      → "This figure compares the relative time scale and magnitude of erosion for the three
      contributing components examined in this study."

L378, Figure 16 caption: "Time scale difference according to erosion occurrence elements."
      → "Relationship between time scale and magnitude of erosion for each of the three
      contributing components of risk potential."

L379:   " First, shoreline retreat due to…" → "First, shoreline retreat W_c due to…"

L381:   "loss rate K_d lost to offshore and the decrease rate α of the sand flowing into the
      beach, which are variables representing the"
      → "loss rate K_c to offshore and the decrease rate α of sediment supply to the beach,
      which are a function of the"

L384:   "where the sand loss rate K_c is given as a constant value,"
      → "where K_c is a constant,"

L385:   "Equation (20) shows that the…."   → "Equation (22) indicates that …"

L386:   " … or more equilibrium when…"   → "… or more of the equilibrium state when…"

L396–397:   "…over 20~40 days per a storm event. …"
      → "… over 20~40 days after each storm."

L397:   "Shoreline retreats when high wave incidence and it recovers again when the wave us
      extinguished." → "Shoreline retreats during storm/high waves and it recovers after
      storm wanes."

L398:   "…converging to wave energy …" → "…converging to swell wave energy…"

L400:   "expressed as the following ODE equation…" → "expressed by an ODE equation…"
L402:   "Here, K_e is the beach recovery factor, and E_b is the wave energy at the breaking point. And a is a beach …"
→ "Here, K_e is a beach recovery factor, E_b is the wave energy at the breaking point, a is a beach…"
L403–404:   "And another factor b, which is proposed by Yates et al. (2009), has little effect, so it is excluded from Eq. (24)."
→ You may delete this sentence because factor b does not appear in Eq. (24).
L404–406:   "… If only the value of the beach recovery factor K_e, which has a unique value for each beach with different characteristics, is known, the temporal change of the shoreline according to wave energy can be estimated using Eq. (24)."
→ "…When the value of K_e, which is unique for each beach, is known, the temporal change of shoreline can be estimated from Eq. (24) for given wave energy."

6. Concluding Remarks

L412:   "… (1989). It is often caused by wave field changes…"
→ "… (1989), resulting from wave field changes…"
L414:   "…was estimated…" → "…is estimated…"
L415–417:   "…from the *encroachment accumulation curve* that accumulates the area to be damaged by…of the buffer section based on the average shoreline. Where the planar beach erosion potential obtained in advance is required to evaluate each consequence components."
→ May be shortened as "…from the *combined erosion potential curve* that represents the risk of beach erosion (area and/or shoreline) from a local mean shoreline."
L418–419:   "by multiplying the consequence and frequency. The frequency for …"
→ "from multiplying the predicted risk potential by the frequency of occurrence for each contributing component. For instance, the frequency for …"
L420–424:   "Through the case analysis….Korea, in which…was recently conducted, the feasibility of methodology presented in this study was reviewed and the major risks of erosion were quantitatively identified. It was interpreted using a series of aerial photographs taken from 1972 to 2017 and survey data obtained from the erosion rating project started in 2010."
→→ "From the case study… Korea, where…has recently been carried out, the applicability of the methodology presented in this study is satisfactorily verified, supported by a series of aerial photographs taken from 1972 to 2017 and beach survey data commenced in 2010."
L424–425:   "As a result, no dam was built in the watershed of the target beach, small-scale weirs were constructed, so the…was judged to be insignificant enough to be difficult to quantitatively express."
→ "Following the construction of several small weirs, rather a large dam, in the watershed for the Bongpo-Cheonjin Beach, the …has become insignificant, hence $W_c \approx 0$."
L425–426:   "In addition, the *longshore sediment deposition potential* was evaluated as 17 m after…by 40 m." → "In addition, an estimated of 17 m is assigned to *longshore sediment deposition potential* (W_d), after… by 40 m."
L427–430:   "…*retreat potential* was evaluated as the value with the range from 5.57 m to 19.75 m ($1\ yr \leq F_e \leq 30\ yrs$). Therefore, if the shoreline retreat which is the sum of individual components is applied to the *encroachment accumulation curve*, the risk potential is obtained as the value with the range from 20.9 m^2 to 4969.4 m^2 (see Fig. 16

and Table 4).”

→→ ““…*retreat potential* (W_e) was estimated within the range from 5.57 m to 19.75 m for the frequency of occurrence (1 yr ≤ F_e ≤ 30 yrs). Applying the total shoreline retreat that represents the sum of (W_c + W_d + W_e) to the *combined erosion potential curve*, it yields the total eroded beach area ranging from 20.9 m² to 4969.4 m² (see Fig. 14 and Table 4). ”.

L430:   “This means that erosion damage to 4,969.4 m^2 area eroded at least once every 30 years can occur, requiring”

→ “This implies that beach area totaling 4,969.4 m² might be eroded once every 30 years, thus requiring…”.

L432–433:   “The erosion risk potential was calculated by applying the standard deviation of 5.5m obtained from the shoreline survey data. As a result, therefore, the peak risk potential of 357.54m^2 occurred at 5 years recurrence.”

→ “Using the standard deviation of 5.5 m obtained from beach survey data for Bongpo-Cheonjin Beach, Fig. 14 shows W_e = 13.57 m, W_t = 30.57 m and C_{5yrs} = 1,787.7 m² for the high waves with 5-year recurrency.

L433–434:   “When the risk assessment method of this study is applied, therefore, it is possible…”

→ “Upon applying the risk assessment method presented in this paper, it is possible …”.

L437–438:   “The methodology proposed here enables the academic and quantitative identification of beach erosion risk and can help devise…”

→ “Moreover, the proposed methodology is helpful not only for assessing beach erosion risk quantitatively but also for devising…”.

L438–440:   “ Although the case analysis of this study is limited, it is necessary to examine the feasibility of the proposed method by steadily applying it to… .”

→→ “Further research is recommended in applying the methodology described in this paper to beaches suffering severe erosion, so that this method can be improved and benefit other coastal communities from applying it.”

***** END of REPORT *****

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